Energising Scientific Endeavour through Science Gateways and e-Infrastructures in Africa - The Sci-GaIA project

Roberto Barbera[1,*], Simon J. E. Taylor[2], Tiwonge M. Banda[3], Bruce Becker[4], Alexandra Cornea[5], Jaran Eriksen[6], Lars L. Gustafsson[6], Amos Nungu[7], Omo Oaiya[8], Bjorn Pehrson[9], Rita Ricceri[1], Mario Torrisi[1]

[1] Department of Physics and Astronomy of the University of Catania,
Via S. Sofia 64, 95123 Catania, Italy
{roberto.barbera,rita.ricceri,mario.torrisi}@ct.infn.it

[2] Brunel University London,
Kingston Lane, Uxbridge, Middlesex UB8 3PH, United Kingdom
simon.taylor@brunel.ac.uk

[3] The Ubuntunet Alliance,
Off Paul Kagame Road, HB House, Block C, P.O. Box 2550, Lilongwe, Malawi
tiwonge.banda@ubuntunet.net

[4] Council for Scientific and Industrial Research, Meraka Institute,
Scientia 627-Jr, Meiring Naude Rd, 0081 Pretoria, South Africa
bbecker@csir.co.za

[5] Sigma Orionis,
Buropolis 1, 1240 route des dolines, 06560 Valbonne Sophia Antipolis, France
alexandra.cornea@sigma-orionis.com

[6] Karolinska Institutet,
Solnavägen 1, 171 77 Solna, Stockholm, Sweden
{jaran.eriksen,lars-l.gustafsson}@ki.se

[7] Dar es Salaam Institute of Science and Technology,
P. O. Box 2958, Dar es Salaam, Tanzania
amosnungu@dit.ac.tz

[8] West and Central African Research and Education Network (WACREN),
11 Aviation Road Extension, P. O. Box 5744, Accra, Ghana
omo@wacren.net

[9] Royal Institute of Technology (KTH),
Kungliga Tekniska Högskolan, SE-100 44 Stockholm, Sweden
bpehrson@kth.se

* Corresponding author.

Abstract. With the AfricaConnect series of projects, the lack of access to e-Infrastructures in Africa by African scientists is going to be tackled and hopefully solved. In the recently ended eI4Africa project it has been demonstrated clearly that it is possible to develop e-Infrastructures in Africa and that easy to use web portals, namely Science Gateways, are needed to help Communities of Practice (CoPs) in various scientific disciplines to easily access e-Infrastructure facilities and through these collaborate with CoPs in Europe and across the world. This paper presents the Sci-GaIA project which is the successor of eI4Africa. Sci-GaIA proposes to create clearly structured guides and educational materials that can be used to train and support representatives of NRENs, CoPs and, importantly, Universities to develop Science Gateways and other e-Infrastructures services. Sci-GaIA also plans to work with new and emerging CoPs to develop these technologies and to strengthen e-Infrastructure service provision, especially in terms of identity federations and open access linked data repositories.

Keywords: e-Infrastructures, Science Gateways, Africa, e-Science, Open Science, Open Science Commons

1 Introduction

In African Communities of Practice (CoPs), international scientific collaboration has faced major barriers with the lack of access to e-Infrastructures and high performance network infrastructure enjoyed by European counterparts. In addition, the limited number of scientists in many disciplines in most African research centres makes access to e-infrastructures and international publications critical, both at institutional and individual level [1, 2]. With AfricaConnect [3], the proposed AfricaConnect2 [4], and the regional developments carried out by both the Regional Research and Education Networks (RRENs) and the National Research and Education Networks (NRENs), this situation is changing rapidly.

In the project "Teaming-up for exploiting e-Infrastructures' potential to boost RTDI in Africa" [5] (eI4Africa), ended on October 2014, it has been demonstrated that it is possible to develop e-Infrastructure services in Africa [6]. It has also been shown that, as with the rest of the world, easy to use web portals, or Science Gateways [7], are needed to help CoPs to easily access e-Infrastructure facilities and through these collaborate with CoPs across the world. However, there is a major problem: it is very difficult for non-experts to develop Science Gateways and deploying and supporting e-Infrastructures and maintaining up-to-date knowledge, contents and applications. Elements of guides and supporting materials exist but these are either written for different audiences or out of date.

The project "Energising Scientific Endeavour through Science Gateways and e-Infrastructures in Africa" [8] (Sci-GaIA), which is topic of the present paper, proposes to bring together these materials into clearly structured guides and educational documents that can be used to train and support representatives of NRENs, CoPs and, importantly, Universities to develop Science Gateways and e-Infrastructures in Africa. Such guidelines will also help scientific communities to gain support with expertise and funding from the globally organized scientific

organizations. This will give a sustainable foundation on which African e-Infrastructures can be developed. Importantly, the results of the project will be usable by CoPs in Europe and the rest of the world. To achieve this we bring together a highly experienced team of beneficiaries [9], led by the Brunel University London, that have worked between Africa and Europe to advance African e-Infrastructures.

The objectives of Sci-GaIA are therefore:

- To promote the uptake of Science Gateways and e-Infrastructures in Africa and Beyond:
  - To create Science Gateway and e-Infrastructure development guidelines and materials for NRENs, CoPs and Universities. It will also monitor the successful implementation and uptake of standard-based Science Gateways and related e-Infrastructure services, such as Policy Management Authorities, Identity Federations and Open Access Document and Data Repositories, in Africa as well as ensuring the interoperability and interoperation between the African, the EU and the global e-Infrastructures.
- To support new and already emerging CoPs:
  - To identify, promote and support both web-based and in-person cooperation between application facilities, service providers, and associated end-user communities that can gain in their fields from using the e-Infrastructure tools fostered and promoted by the project. This will also identify innovations and experiences made in the supported user-communities as well as the need for planning, development and coordination of policies, programmes and contents of Science Gateways and e-Infrastructures within these communities and in collaborations with important stakeholders such as NRENs.
- To strengthen and expand e-Infrastructure and Science Gateway related services:
  - To expand and extend activities carried out in past projects in order to consolidate the African e-Infrastructure services and to include the very challenging goal of supporting the creation of an African Open (and Linked) Data Infrastructure, interoperable with and federated to (through the adoption of international standards and guidelines) those being consolidated in the EU and in other regions of the world. Sci-GaIA also aims at exploiting Open Access repositories together with Science Gateways in order to deal with very important topics such as the discoverability, reproducibility and extensibility of science products. All this will make African science and scientists more visible and will allow the extension of the principles of the European Research Area well beyond its southern border.
- To train, disseminate, communicate and outreach:
  - To run training and dissemination events for Science Gateway and e-Infrastructure development and to showcase how CoPs can develop their gateways and infrastructure services, in tight collaboration with NRENs and Universities for long sustainability purposes. To disseminate project outcomes with the intense communication of its achievements and activities across Africa and beyond and with the

publication on Open Access journals of the proceedings of User Fora and other important events.

The paper is organised as follows. Section 2 presents the workplan of the project as well as its expected impact while Section 3 reports on the current status of the activities and corresponding outcomes. Summary and conclusions are drawn in Section 4.

2 Workplan and expected impact

Sci-GaIA aims to build on e-Infrastructure investments in Europe bringing together the results of many e-Infrastructure projects/initiatives (e.g., EGI [10], eI4Africa [5], CHAIN-REDS [11], GEANT [12], OpenAIRE [13], etc.), to create training materials that will support the development of international CoPs, first in Africa and then in Europe and beyond. The project will promote sound policy development by reflecting results from stakeholder consultation via CoPs and monitor the uptake of Science Gateways and e-Infrastructures in Africa and through these developments coordinate international policies and programmes for e-Infrastructures. In particular, it will focus on the cooperation and facilitation of European e-Infrastructures with their emerging African counterparts to ensure global interoperation, interoperability and outreach based on the adoption of both de jure and de facto standards, as well as widely shared guidelines and best practices.

In order to reach the challenging objectives listed above and in the previous section, the consortium of partners has conceived a well structured action plan that is outlined in the following sub-sections.

2.1 Promote the uptake of Science Gateways and e-Infrastructures in Africa and beyond

Building on some existing component, Sci-GaIA is supposed to develop a coherent and consolidated guide and produce training and educational materials (that can be used (i) to develop e-Infrastructures by NRENs and (ii) to develop Science Gateways by both NRENs and CoPs. These will then be used to create materials usable in education programs by Universities in technological degrees and specific domain areas (we limit ourselves initially to Life Science and Healthcare and to Environmental Monitoring, Agriculture and ICT infrastructure in under-served rural areas in East and West Africa as we see these as being key to the early adoption of these technologies by African scientists and can leverage many advantageous connections and collaborations with Europe). Care will be taken to monitor the impact of these activities, as well as ensuring the interoperability and interoperation of these technologies with global e-Infrastructures.

2.2 Support new and already emerging communities of practice

We will develop a collaborative user forum to help developers and users of these technologies to communicate and share information and experiences. Building on experiences and contacts from previous projects and using training materials being developed by the project we will work with emerging CoPs in Life Sciences and Healthcare to help building Science Gateways. This will test our training material as well as helping to "jump start" Science Gateways in Africa (as well as creating demonstrators for our workshops). Experiences from this work will build momentum to reach out and work with new CoPs, initially from Environmental Monitoring, Agriculture and ICT infrastructure in under-served rural areas in East and West Africa. We will also attempt to reach a wider impact of these technologies on society by attempting to establish a "Living Lab" with stakeholders across a representative African district and building on experience with the Serengeti Living Lab. We shall also work with Universities in the Technology Transfer Alliance [14] (TTA) to embed education materials created by the project in courses and the definition of student projects to support Science Gateway development.

2.3 Strengthen and expand Science Gateway and e-Infrastructure related services

The Sci-GaIA workplan includes the challenging goal of supporting the creation of an African Open (and Linked) Data Infrastructure, interoperable with and federated to (through the adoption of international standards and guidelines) those emerging in EU and in other regions of the world. This will also combine Open Access repositories with Science Gateways in order to deal with very important topics such as the discoverability, reproducibility and extensibility of science products. Our work on Certification Authorities and Identity Federations will continue by building on successful African NREN deployments and deploying these key e-Infrastructure components across more African NRENs. To give a concrete foundation for Science Gateway development in Africa, the Africa Grid Science Gateway developed in eI4Africa will be fully ported and deployed at the Dar es Salaam Institute of Technology in Tanzania.

2.4 Train, disseminate, communicate and outreach

The guides developed by the project will be used "on the field" to train people, both from NRENs and CoPs, as well as from University course owners. As a side effect of the training events, applications integrated in the Science Gateways will become demonstrators to be showcased at the workshops organised by the project. One face-to-face Summer School in Europe and one entirely web-based Winter School will also be organised and delivered in July and March 2016, respectively. The webinars will enable African computer scientists and software engineers from across the whole continent to participate. The Summer School will be 2-weeks long. The three Sci-GaIA 2-day workshops will also be organised by UBUNTUNET, in

conjunction with UbuntuNet-Connect 2015, by WACREN, in conjunction with the WACREN General Assembly 2016, and by the Dar es Salaam Institute of Technology, in conjunction with the 2016 Technology Transfer Alliance Conference. A final conference and a peer-reviewed user forum event will disseminate the scientific results of the project, as well as the successful developments achieved during its lifetime. These and a coordinated dissemination and communication program will show how materials developed in the project have successfully supported Science Gateway and e-Infrastructure development.

2.5 Expected impacts

Sci-GaIA is expected to have a substantial impact on the scientific and technological collaboration between Europe and Africa in several domains and on important topics such as e-Infrastructure creation and operation and extension of the so-called European Research Area (ERA) beyond the southern border of Europe. The adoption of the Science Gateway paradigm and the exploitation of standards such as SAML [15] for authentication, SAGA [16] for the interface of applications to the various e-Infrastructures' middleware, and OCCI [17]/CDMI [18] for Cloud computing/storage access, will allow users to seamlessly access and use Grid, Cloud and local HPC services, both in Europe and Africa providing easiness to collaborate within all scientific disciplines across distances.

Furthermore, Sci-GaIA will make African (as well as European) research and researchers more "visible" worldwide and will contribute to the nowadays key topic of discoverability, reproducibility and extensibility of science products (also by the so-called "citizen scientist"). Moreover, worldwide standards (such as Semantic Web's [19], Linked Data's [20], OAI-PMH [21], etc.) and widely accepted guidelines defined in Europe (such as those of EUDAT [22] and OpenAIRE [13]) on Open Access and Data Preservation will be promoted in order to achieve a better interoperation and interoperability of e-Infrastructures, including especially Open Data Infrastructures.

Last but not least, Sci-GaIA will contribute to the creation of didactic materials that will eventually be included in official curricula that will be usable in Africa, Europe and beyond.

The above impacts will be measured by the following quantitative indicators. Sci-GaIA will support the creation/establishment of:

- At least 3 new Science Gateways in Africa;
- At least 2 new University courses on Science Gateways;
- At least 10 lectures delivered at Universities within CoPs on Science Gateways;
- At least 10 international student-led projects on Science Gateway development led by the TTA [14];
- 1 Policy Management Authority (PMA), the AfricaPMA, that will be a member of IGTF [23] and will gather all Certification Authorities already established (and to be established) in the continent;

- At least 3 official national Identity Federations with at least 3 Identity Providers and at least 3 Service Providers each; the Identity Federations will join the eduGAIN inter-federation [24];
- 1 Member of a Registration Agency for the issuance of permanent unique identifiers (either DOIs [25] or PIDs [26]) to research products (papers, data, software, etc.);
- At least 30 new Open Access Document/Data Repositories in Africa;
- At least 100 Open Access Document/Data Repositories compliant with the OpenAIRE Guidelines [27] and include them in the OpenDOAR [28] and OpenAIRE [29] lists of official providers.

3 Current status

3.1 Introductory concepts and driving considerations

After more than 20 years since its birth, it is commonly believed that the Web is now entering its second or even third evolution phase. According to [30] , *"[…] Web 3.0 might be defined as a third-generation of the Web enabled by the convergence of several key emerging technology trends: […] Ubiquitous Connectivity, Network Computing, Open Technologies, Open Identity, and the Intelligent Web"*.

This plethora of new services and capabilities of the web are having a big influence also on science. In all disciplines, methods of doing research and create and share knowledge are becoming more and more "digital" and, in analogy with Web 2.0, they are grouped under the term "Science 2.0" or, from those promoting free knowledge, under the terms "Open Knowledge" or "Open science". According to a recently published seminal book [31]:

- *"Science 2.0 refers to all scientific culture, including scientific communication, which employs features enabled by Web 2.0 and the Internet;*
- *Open Science refers to a scientific culture that is characterized by its openness. Scientists share results almost immediately and with a very wide audience."*

Five schools of thought on Open Science have been identified so far [31], characterised by their central assumptions, the involved stakeholder groups, their aims, and the tools and methods used to achieve and promote these aims.

The **infrastructure school** is concerned with the technical infrastructure that enables emerging research practices on the Internet, for the most part software tools and applications, as well as computing networks. The infrastructure school regards Open Science as a technological challenge and focuses on the technological requirements that facilitate particular research practices, such as Grid and, more recently, Cloud Computing.

Within this very fertile, exciting and fascinating landscape, paving the way for a second scientific revolution, the breakthrough concept of Open Science Commons

[32] is emerging as the ensemble of management principles that may actually implement Open Science guidelines. According to the Open Science Commons principles, *"research data, scientific instruments, digital services (including those for data-intensive science), software, written knowledge (e.g., scientific publications, educational and training resources), expertise from people"*, etc. are openly and widely shared across virtual research communities encompassing a variety of different disciplines.

Due to the huge importance of the above concepts and the key role they can play for the development of Africa and for making science "made in Africa" more visible worldwide, most of the work carried out by Sci-GaIA in its first months has been concentrated on setting up an Open Science Commons Platform for Africa comprising all the tools and services needed to enable Open Science workflows.

The most important components of the platform are depicted in Fig. 1 and presented in the next sub-section.

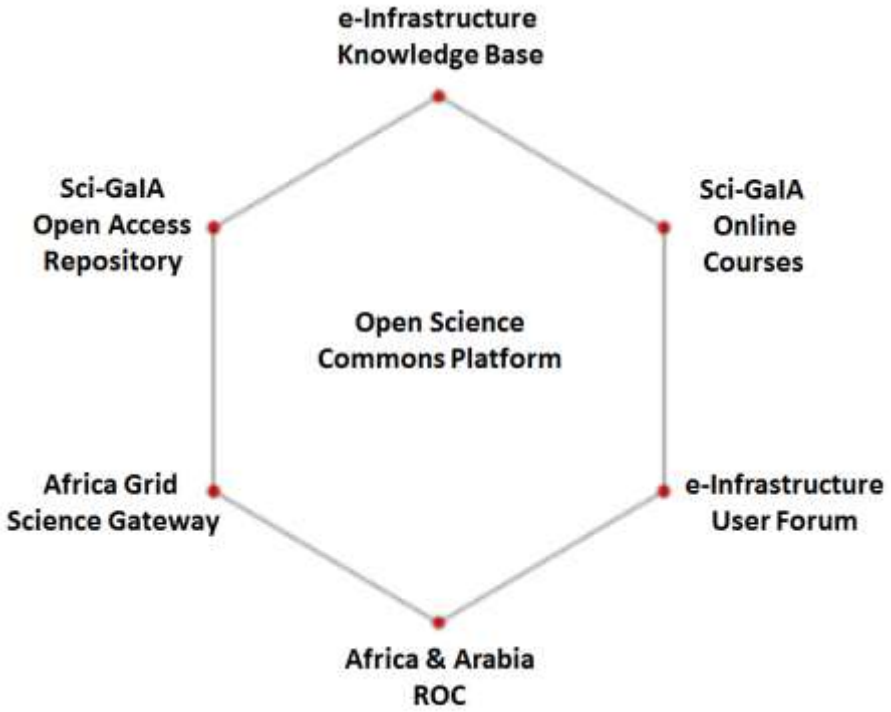

Fig. 1. The components of the Sci-GaIA Open Science Commons Platform.

3.2 The components of the Sci-GaIA Open Science Commons Platform

The e-Infrastructure Knowledge Base

Sci-GaIA plans to re-use and extend the e-Infrastructure Knowledge Base (KB) built in the context of the past EC funded CHAIN-REDS project containing more than 4,000 Open Access Document and Data Repositories as well as almost 200 digital

archives of Open Educational Resources worldwide, for a total of more than 30 million resources, including a Linked Data search engine able to discover non-previously known correlations between data and documents.

In the first months of the project, the KB has been completely re-engineered from the software point of view and a RESTful API has been developed from scratch. This has made the integration of the KB inside the project website very smooth and the front-end maps and tables can already be inspected at [33].

The Sci-GaIA Open Access Repository

A general purpose Open Access Repository (OAR) [34] has been made available as an Open Science Commons. OAR is powered by the standard-based and widely used INVENIO software [35] and is conforming both with OAI and OpenDOAR specifications (through the adoption of the OAI-PMH standard for metadata harvesting). OAR is compliant with version 3.0 of OpenAIRE guidelines mentioned above, allows SAML-based federated authentication and it will soon be registered in the eduGAIN inter-federation and connected to either a DataCite [36] or a Handle.Net [26] registry domain for the issuance and registration of either DOIs or PIDs. It also allows users to share their unique researcher ID's (.e.g, ORCID [37]). But what makes OAR really different from other repositories is its capability to connect to Science Gateways (such as the one described in next paragraph) and exploit Distributed Computing and Storage Infrastructures worldwide to easily reproduce and extend scientific results.

It is worth noting here that the Sci-GaIA OAR contains, as one of its records, the virtual machine with everything installed to clone itself. This will help spreading the deployment of Open Access Repositories in Africa.

The Africa Grid Science Gateway

The Sci-GaIA portfolio of services includes the Africa Grid Science Gateway [38] able to: (i) seamlessly access various e-Infrastructures in a way that is transparent for end users and (ii) support the so-called long tail of science (i.e. the small groups or even single researchers that do not belong to the large Virtual Research Communities). The Africa Grid Science Gateway is implemented with the Catania Science Gateway Framework [39] (CSGF), a standard-based framework to build Science Gateways, both web based and as apps for mobile appliances. Exploiting SAGA, SAML, OCCI and CDMI standards, the CSGF allows users to access distributed computing infrastructures using their federated identities and application to seamlessly run on Grid, Clouds and local HPC clusters.

The Sci-GaIA Online Courses

The above mentioned training and education materials that will be either gathered or developed by the project and the curricula that will be built based on them will be provided to students through an e-learning environment based on OpenEdx [40], a next-generation Learning Management System (LMS) and courseware platform that is quickly becoming a "de facto" standard for Massive Open Online Courses (MOOCs).

The Sci-GaIA Online Courses server is already online at [41] and it is being customised to support federated authentication. It will be open to both teachers and

students after September 2015. Such online courses could even be of great importance for rebuilding academic structures in severely war-hit countries such as Somalia for which a call for international action among academic institutions and Somalia diaspora has been recently launched [42].

The Africa & Arabia ROC

e-Infrastructures are key components of the infrastructure school of thought for Open Science. Sci-GaIA pays a lot of attention to this and is one of the main supporters of the Africa & Arabia Regional Operations Centre (ROC) [43]. The mission of Africa and Arabia ROC is to promote and support collective, coherent and sustainable interoperability of e-Infrastructures within Africa and beyond, to peer infrastructures in the rest of the world; and to act as a point of coordination and support to computational resource providers in the region, in order to promote and develop regional scientific and technical collaboration.

The e-Infrastructure User Forum

In order to let all Open Science actors to freely and openly discuss a large variety of topics, Sci-GaIA has set-up a web forum [44] based on the innovative Discourse platform [45].

The forum is organised around many different topics and aims at: discussing technical matters, such as the interoperability of African and EU e-Infrastructure services and/or the issues and the results of the supported applications and/or the training programmes. It fosters scientific discussions on how applications already included or to be included in the Science Gateways can help tackling specific problems and topics and hosts political debates on the sustainability of e-Infrastructures in Africa and on the opportunities for further funding and for jobs.

4 Summary and conclusions

The Sci-GaIA project is funded by the European Commission under the Horizon 2020 Research and Innovation Programme. It has a very ambitious and challenging workplan aiming to make a breakthrough in scientific research in Africa.

In the first four (at the time of writing) months, the project has already made a substantial progress and its strong attention to setup an Open Science Commons Platform for Africa is very strategic and will be rewarding for the entire continent in the long term. Communities of Practice, decision makers, stakeholders and even single researchers or simple citizen scientists can help steering and improving our activities regarding the promotion of e-Science and Open Science in Africa. On this purpose, everybody is welcome to fill the just published survey for monitoring the implementation and uptake of e-Infrastructures in Africa [46].

References

1. Loukanov, S., Prytherch, H., Blank, A., Duysburgh, E., Tomson, G., Gustafsson, L. L., Sié, A., Williams, J., Leshabari, M., Haefeli, W. E., Sauerborn, R., Fonn, S.: Nesting doctoral students in collaborative North-South partnerships for health systems research. Global Health Action 2014;7:24070. DOI: 10.3402/gha.v7.24070. eCollection 2014.
2. Dandara, C., Huzair, F., Borda-Rodriguez, A., Chirikure, S., Okpechi, I, Warnich L,Masimirembwa C. H3Africa and the African life sciences ecosystem: building sustainable innovation. OMICS. 2014;18:733-9.
3. The AfricaConnect Project, http://www.africaconnect.eu
4. The AfricaConnect2 Project, http://www.africaconnect.eu/MediaCentre/Pages/AfricaConnect2.aspx
5. The eI4Africa Project, http://www.ei4africa.eu
6. Spyridonis, F., Taylor, S. J. E., Abbott, P., Barbera, R., Nungu, A., Gustafsson, L. L., Pehrson, B., Oaiya, O., Banda, T. M.: A study on the state-of-the-art of e-infrastructures uptake in Africa. Palgrave Communication 1 (2015). DOI:10.1057/palcomms.2014.7. http://www.palgrave-journals.com/articles/palcomms20147
7. By definition, a Science Gateway is a "community-development set of tools, applications, and data that is integrated via a portal or a suite of applications, usually in a graphical user interface, that is further customized to meet the needs of a specific community", http://sciencegateways.org/what-is-a-science-gateway
8. The Sci-GaIA Project, http://www.sci-gaia.eu
9. The Sci-GaIA Consortium, http://www.sci-gaia.eu/about-us/project-partners/
10. The European Grid Infrastructure, http://www.egi.eu
11. The CHAIN-REDS Project, http://www.chain-project.eu
12. The GEANT Association, http://www.geant.org
13. The OpenAIRE Project, https://www.openaire.eu
14. The Technology Transfer Alliance, http://www.ttaportal.org
15. The Security Assertion Markup Language (SAML) Standard, http://saml.xml.org
16. The Simple Api for Grid Applications (SAGA) Standard, http://www.gridforum.org/documents/GFD.90.pdf
17. The Open Cloud Computing Interface (OCCI) Standard, http://occi-wg.org
18. The Cloud Data Management Interface (CDMI) Standard, http://www.snia.org/cdmi
19. The Semantic Web Standards, http://www.w3.org/2001/sw/wiki/Main_Page
20. The Linked Data Standards, http://www.w3.org/standards/semanticweb/data
21. The Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) Standard, http://www.openarchives.org/pmh
22. The EUDAT Project, http://www.eudat.eu
23. The Interoperable Global Trust Federation (IGTF), http://www.igtf.net
24. The eduGAIN Inter-federation, http://www.edugain.org
25. The Digital Object Identifier (DOI) System, http://www.doi.org
26. The Handle System for Persistent Identifiers (PIDs), http://www.handle.net
27. The OpenAIRE Guidelines, http://guidelines.openaire.eu
28. The OpenDOAR Initiative, http://www.opendoar.org
29. The OpenAIRE Data Providers, https://www.openaire.eu/search/openaire-data-providers
30. Spivack, N.: Web 3.0: The Third Generation Web is Coming. http://lifeboat.com/ex/web.3.0
31. Fecher, B., Friesike., S.: Open Science: One Term, Five Schools of Thought. A chapter of: Opening Science – The Book. DOI: 10.1007/978-3-319-00026-8. http://book.openingscience.org

32. Andreozzi, S., Appleton, O., Coelho, S., Ferrari, T., Holsinger, S., Legré, Y.: Open Science Commons. http://www.egi.eu/news-and-media/publications/OpenScienceCommons_v3.pdf
33. The Sci-GaIA Knowledge Base, http://www.sci-gaia.eu/e-infrastructures/knowledge-base
34. The Sci-GaIA Open Access Repository, http://oar.sci-gaia.eu
35. The INVENIO Software for Digital Repositories, http://invenio-software.org
36. The DataCite Organisation, http://www.datacite.org
37. The ORCID Initiative, http://www.orcid.org
38. The Africa Grid Science Gateway, http://sgw.africa-grid.org
39. The Catania Science Gateway Framework, http://www.catania-science-gateways.it
40. The OpenEdx Platform, https://open.edx.org
41. The Sci-GaIA Online Courses, http://courses.sci-gaia.eu
42. Ivarsson, I., Kinsman, K., Johansson, K., Mohamud, K. B., Weinehall, L., Freij, L., Wall, S., Dalmar, A. A., Ahmed, A., Ibrahim, A. O., Hagi, A., Abdi, A. A., Hussein, A. S., Shirwa, A. M., Warsame, A., Ereg, D. I., Aden, M. H., Qasim, M., Elmi, A., Afrah, A. W., Sabtiye, F. O., Guled, F. E., Ahmed, H. J., Mohamed, H., Tinay, H. A. , Mohamud, K. A., Yusuf, M. W., Omar, M., Abdi, A. Y., Abdullkadir, Y., Johansson, A., Kulane, A. A., Schumann, B., Essen, B., Kalengayi, F. N., Elgh, F., Norstrom, F., Lonnberg, G., Norder, H., Schroders, J., Erlandsson, K., Edikn, K., Sahlen, K. G., Gustafsson, L. L., Persson, L. A., Eriksson, M., Emmelin, M., Hasselberg, M., Klingberg, M., Preet, R., Hogberg, U., Sjoström, U., Omar, S.: Healing the health system after civil unrest. Global Health Action 2015; 8: 1-4.
43. The Africa & Arabia Regional Operation Centre, http://www.africa-grid.org
44. The e-Infrastructure User Forum, http://discourse.sci-gaia.eu
45. The Discourse Platform, http://www.discourse.org
46. The Sci-GaIA Survey for Monitoring the implementation and uptake of e-Infrastructures in Africa, http://surveys.sci-gaia.eu/index.php/531683?lang=en